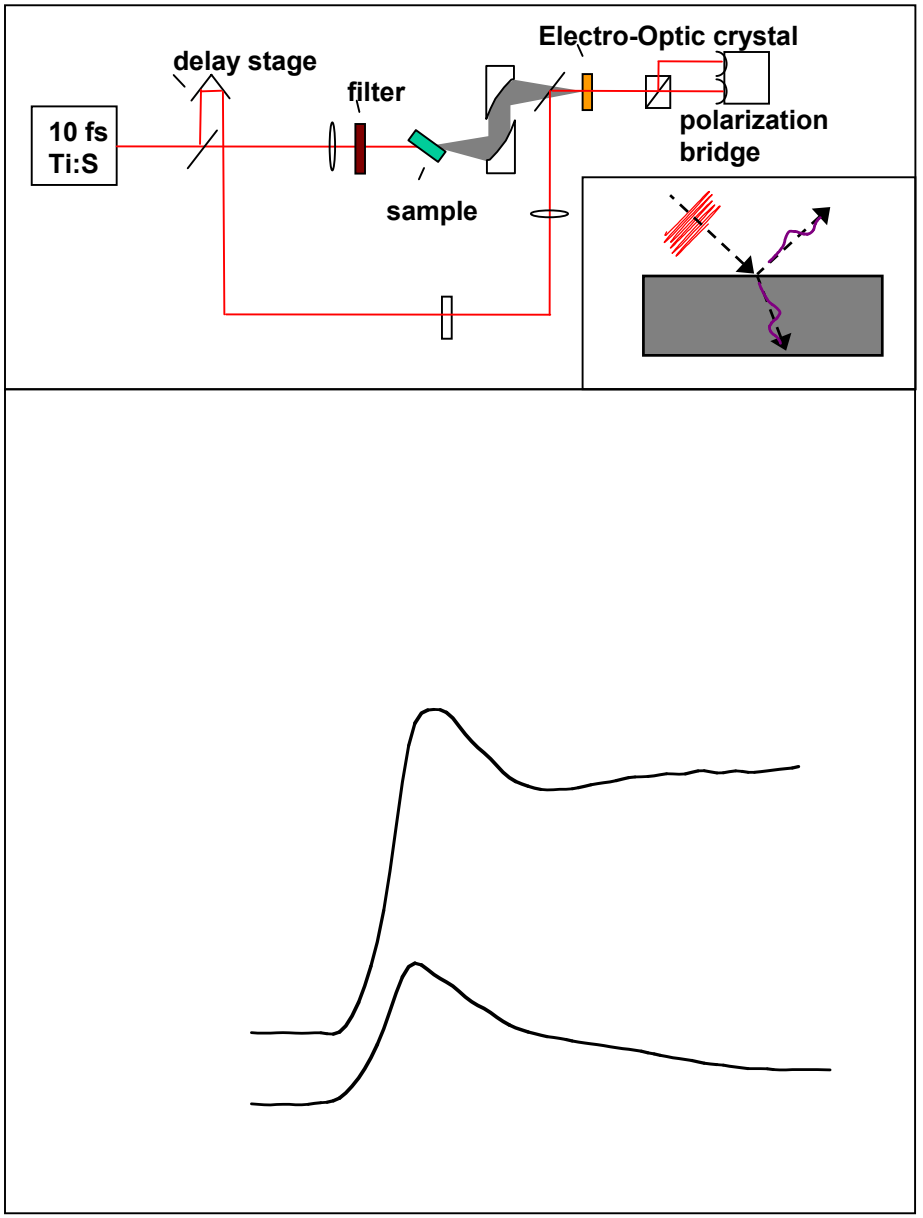
Ultrafast THz Spectroscopy of Carrier Dynamics in Semiconductors

Prof. James Heyman, Macalester College, DMR 0317276

We use ultrafast optical techniques to investigate charge transport in photoexcited semiconductors on picosecond time-scales. This information is important to the development of high speed opto-electronics.

In our time-resolved THz emission experiments, THz frequency electromagnetic waves are generated when electrons in a semiconductor are impulsively excited by a femtosecond laser pulse. This radiation is then used to probe the motion of electrons on very short time-scales. Here we extract the average electron velocity versus time following excitation for different electric fields. These preliminary data show ballistic acceleration followed by velocity overshoot and drift. Plasma oscillations are observed at high electric fields.



Heyman, et. al., APL 83, 5476, 2003

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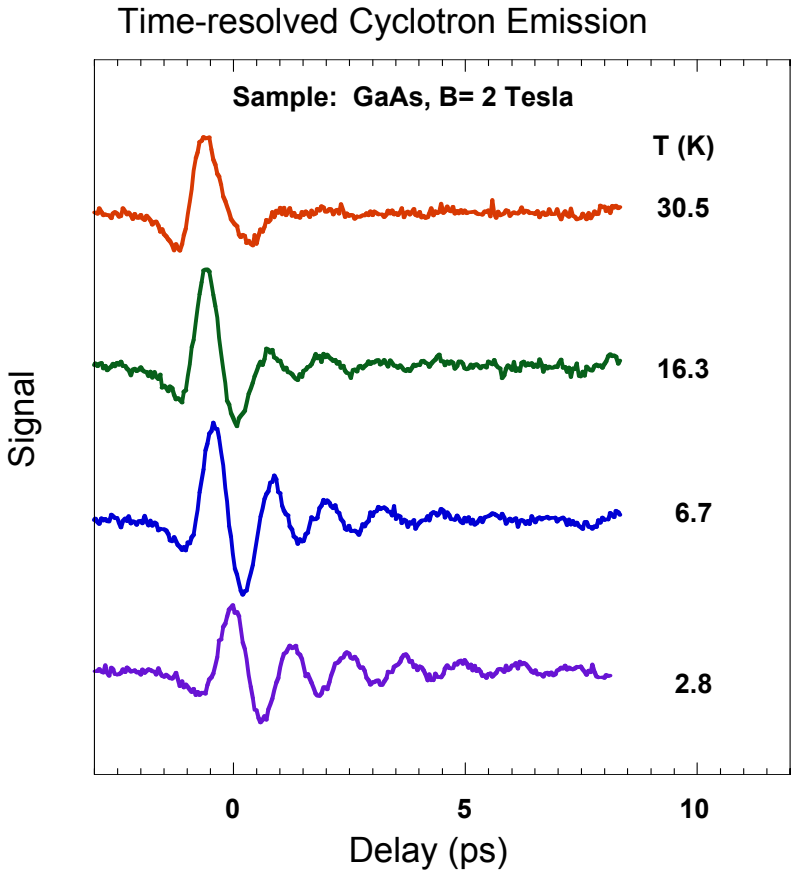
This project supported two undergraduate research assistants in Summer, 2003, and four in Summer, 2004. Alex Reinhardt, Sheila Nabanja, Dauda Mawanda and Biniyan Taddasse are completing Physics Majors at Macalester. Nelson Coetes (‘03) and Marc Robins (‘04) are planning to apply for graduate studies in engineering. Nelson is continuing as a research assistant with the PI during 2004/05.

THz magneto-spectroscopy gives additional information about carrier effective masses and scattering rates.

Here we use THz emission in a magnetic field to study cyclotron radiation from GaAs. The electron effective mass determined by these measurements is $m^* = 0.068 \cdot m_0$. We see a strong dependence of the dephasing rate with temperature.

Future work will investigate variation of scattering rates with electric field and excitation energy in different semiconductor materials.



THz emission from InAs at *f* and *2f*

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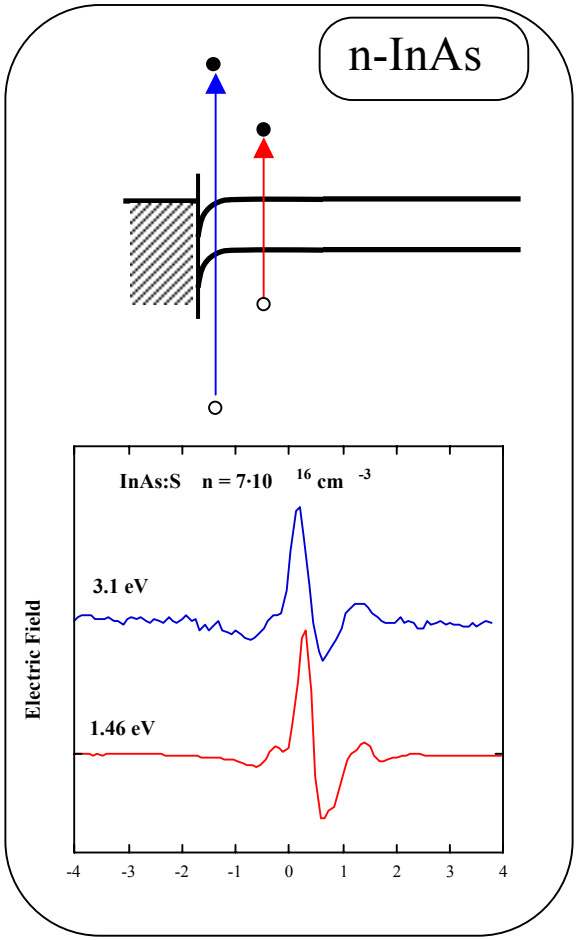
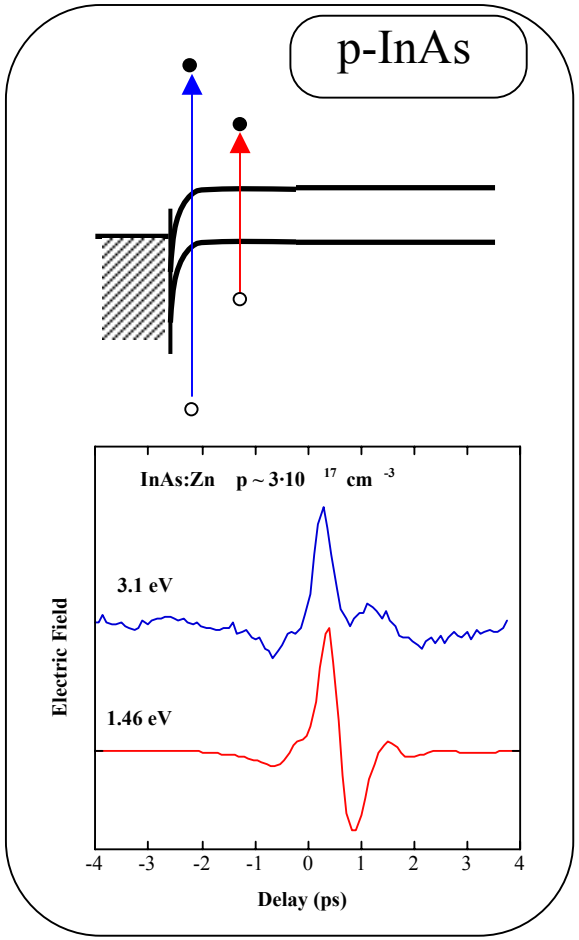
THz emission from InAs seems Dember field dominated under all conditions measured





Conclusions

Drift and Hot-Carrier Diffusion power THz emission from GaAs.

We can switch from Drift dominated to Diffusion-dominated transport in single sample.

Hot-Carrier Diffusion powers THz emission from InAs.

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